

---

# HCI and mHealth Wearable Tech: A Multidisciplinary Research Challenge

**Lucretia Williams**

University of California, Irvine  
Department of Informatics  
Irvine, CA, USA  
lucretiw@uci.edu

**Gillian R. Hayes**

University of California, Irvine  
Department of Informatics  
Irvine, CA, USA  
gillianrh@ics.uci.edu

**Yuqing Guo**

University of California, Irvine  
School of Nursing  
Irvine, CA, USA  
gyuqing@hs.uci.edu

**Amir Rahmani**

University of California, Irvine  
School of Nursing  
Irvine, CA, USA  
a.rahmani@uci.edu

**Nikil Dutt**

University of California, Irvine  
Department of Computer  
Science  
Irvine, CA, USA  
dutt@uci.edu

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

*CHI'20 Extended Abstracts, April 25–30, 2020, Honolulu, HI, USA*

© 2020 Copyright is held by the owner/author(s).

ACM ISBN 978-1-4503-6819-3/20/04.

<https://doi.org/10.1145/3334480.3375223>

**Abstract**

This paper explores the challenges of HCI work within multidisciplinary research projects across health sciences, social sciences, and engineering, through discussion of a specific case study research project focused on supporting under-resourced pregnant women. Capturing the perspectives of community-based health care workers (N=14) using wearable technology for servicing pregnant women provided insight into considerations for technology for this specific population. Methods of inquiry included design and development of a prototype wearable and mobile system as well as self-report via a survey detailing their experience with the system and how it can possibly benefit their duties of monitoring their pregnant patients. The process outcomes of this work, however, provide broader insight into the challenges of conducting this kind of interdisciplinary work that remain despite decades of effort and financial investment to support interdisciplinary research, particularly in health informatics and interactive technologies for health.

**CSS Concepts**

• **Human-centered computing** → **HCI design and evaluation methods**

**Author Keywords**

Maternal health care; Wearable Technology; HCI

## Introduction

Women living in underserved communities with low socioeconomic status (SES) are more at risk for experiencing adverse outcomes in pregnancy [1]. Despite advancements in maternal health care, there are still gaps in access to adequate health care and resources for pregnant women living in low income communities [2]. With the increase of technological developments in health care, researchers have deployed various technology interventions into this space. Furthermore, numerous various funding agencies support these engagements. In the case of our own work, talented and experienced systems researchers began working with clinical researchers on the project early, recognizing the need for HCI research as an added element only after initial prototypes had been developed. In this case study, we reflect on the impact of those decisions and how we can improve such engagements going forward.

Interdisciplinary collaboration (health science and technology) creates great value to mobile health (mHealth) research [3]. However, such research can be limited in terms of engagement with the HCI, usability, and user experience communities [4]. HCI as a field draws from a variety of approaches, methods, and theoretical framings to support user perspectives. In turn, the findings resultant from these methods can provide insight to the design and evaluation processes of such interventions. Despite research on *why* HCI should be integrated into interdisciplinary collaborations between health science and technology [5], there is limited work focused on the *how*.

This paper seeks to address this challenge by reflecting on the processes by which user experience was

engaged in a single research project focused on use of an innovative technological solution in support of a clinical population in need. In particular, we present findings from the perspective of community-based health care workers evaluating wearable technology for monitoring the health of pregnant women in low income communities. We then reflect on how these findings relate to and might be addressed by research in the broader HCI community. Finally, we identify ways in which HCI researchers might seek to make their potential contributions better known to collaborators to more usefully engage in the design and research process for those interdisciplinary scholars who seek to work with the HCI community.

## Background

Community health care workers are the liaisons between health care resources and the communities they serve, much like HCI researchers and practitioners are often the liaisons between clinical and systems researchers. Initiatives are put in place for disadvantaged populations to have the most interactions with community health care workers because of the health barriers in their communities [6]. In recent years, mobile application tools have been developed and deployed to help community health care workers address health monitoring challenges in low income areas.

However, very little research has been done to understand its effectiveness. For example, community health care workers commonly use mobile technology to collect field-based health data, receive alerts and reminders, and facilitate health education, often requiring them to participate in the design and evaluation process [7]. Commonly, mHealth programs



Figure 2: Oura smart ring



Figure 1: Samsung Galaxy smart watch

emerge from a strongly clinical perspective, focusing on engaging community healthcare workers and asking them to adhere to evidence-based protocols, policies, and procedures. With limited support from home agencies, managers, and other community health care workers, these projects can be challenging. Overall, community health care workers play a pivotal role in providing resources for individuals living in low-income communities and possess considerable insight to the communities they serve.

For general populations, wearable devices have been used to monitor health and lifestyle, but this approach is only now emerging in support of monitoring maternal health care. Wearable technology has successfully been implemented in the general population but poses some challenges within the population of pregnant women. Major challenges lie within within the design of software and applications that manage physiological adaptations, behavioral adjustments and clinical tracking during childbirth. Currently there is no real solution to accurately measure the various behavioral lifestyle changes during pregnancy [8]. Usually the design criteria for wearable devices involve which hardware components and software should be used rather than the needs of its users.

### Methods

All participants in this study were recruited from MOMS Orange County through our community partnership. Fourteen community-based health care workers who are employed at MOMS Orange County volunteered to be a part of this study. The participants were all females between the ages of 30-50.

We first conducted a thirty-minute workshop teaching the community-based health care workers about the two wearable devices they will be using for this study. Specifically, we presented details instructing participants to unbox and set up the Samsung Galaxy Smart Watch and the Oura Smart Ring. The workshop started with an overview of the study and expectations. A walk through with printed out instructions on how to set up each device as well as its benefits were given to the participants. The intentions of this workshop was to make sure that all of the participants were aware of all of the features and had a working knowledge of the two wearable devices. We also wanted to ensure that all of the participants were able to leave the workshop with devices that were ready for immediate use.

For two weeks immediately following this training session, the participants were instructed to use and incorporate the smart watch and ring into their daily routine. Upon completion of the study the participants were asked to complete an online survey detailing their experience with the wearable devices.

### PRELIMINARY FINDINGS

In the following sections we describe two major insights from the perspectives of community-based health care workers.

#### Barriers of smart wearable technology for monitoring the health of pregnant women

Survey responses shown that the main obstacles for the use of wearable devices for this population relate to their size and physical form. In particular, pregnant women undergo substantial changes to their bodies, such as swollen fingers, that make wearing devices



Figure 3: External App of the Oura smart ring

different from at other times in their lives. The smart watch was deemed to be heavy on the wrists of the participants, and the smart ring was too thick to be comfortable. Finally, as has been a challenge in a variety of other wearable technology research [9], the thick and cumbersome nature of the ring—required by its technological underpinnings—was not deemed stylish by participants.

The novelty of these devices may mean that few people already know how to use them, much less the application built on top of them. The Samsung Galaxy smartwatch has many different features (e.g. step tracker, heart rate, exercise activity steps) that require some technological savvy to use. Likewise, to view data produced by the Oura smart ring, an external app must be downloaded on a smartphone and understood.

These results are likely not surprising for HCI researchers, particularly those who have been focused on motherhood [10], pregnancy [11] and feminist orientations to research [12]. However, what is notable here is that the origins of the project emerged from outside HCI, in a collaborative project with experts from embedded systems and from community health. Despite being a grant-funded project that has been subjected to intense peer review and having enormous expertise, these basic pieces of design that have already been published elsewhere were missed. We note this not to critique the research team, of which we were a part, but to highlight the difficulty in achieving true interdisciplinary research that produces substantial computing research, health sciences outcomes, and HCI contributions. This kind of team science is simply challenging to execute successfully, and these results

indicate just how some of these challenges can be overlooked or underestimated.

### Benefits of smart wearable technology for monitoring the health of pregnant women

Even though there were critical usability challenges with the smart wearable technology chosen, there are some overall benefits to this population seen in our pilot trial. Overall, participants reported that the technologies would likely help the pregnant women become more accountable and aware of their health, knowing their activity level, and sleep patterns.

The benefits of using the devices were expressed by participants during the study:

*"I think it would be helpful in keeping pregnant women more accountable in maintaining some type of fitness activity and more aware of their sleep and how that can factor into their mood for the following day."*

*"I think it might be useful for clients to see how their activity level is and how their test is doing. I think it would motivate for them to move and make them more aware of their habits."*

Being asked by a clinician to track your health remotely can promote responsibility and awareness within pregnant mothers [13]. Maintaining and monitoring physical activity levels and sleep health were the main important features highlighted by participants. Future work will test these assumptions with pregnant women directly.

## Discussion

HCI has grown in scope by incorporating a variety of disciplines (e.g., psychology, sociology, nursing, health sciences) [14], which each have innovative ideas for integrating technology into research. However, these varied disciplines frequently lack the expertise required to design these technological interventions in a user-centered way. HCI works best as a bridging discipline when considered in the early stages of research.

New technology advancements are often made for a generalized population within a specific population, meaning that technology cannot always benefit everyone. The Samsung Galaxy watch and Oura ring are wearable technologies for the general population but ultimately not ideal for pregnant women. The wearable devices used in this study were chosen based on the criteria of devices that were waterproof, had proper sizing, allowed long term monitoring, and was open source. The usability of these devices for their population, pregnant women, were not a part of the criteria. Using an HCI approach will contribute to the understanding of all of the challenges arisen in this project. HCI will present greater insights on why technological systems fail in real-world settings with emphasize in examining users routines, attitudes, and expectations [4]. Uncovering the answers to questions on why people use certain systems the way they do, when and when not they choose to use them, and what other things they would like see implemented in the system will allow great interdisciplinary research to be conducted. By having these questions answered we will then be able to create technology for the needs of its user and their life routine [15].

Despite substantial expertise in wearable and embedded systems as well as clinical nursing practice, some challenges to the user experience of the intervention were missed in this work. A typical HCI research approach would likely have included interviews of pregnant mothers, design exercises, or some other formative user experience work in the earlier stages of research. Given the strong experience, knowledge, and good intentions of the research team, it is worth reflecting on the way in which this step was skipped in this project. HCI researchers and practitioners must make this kind of work better understood to our partners on both the clinical and systems side of such interdisciplinary projects. Additionally, a cultural shift already being undertaken with efforts in holistic and patient-centered medicine that goes beyond traditional lab and evidence-based models may support this kind of engagement [16].

Notably, we do not claim that health technology research should be solely patient-centered. For example, in our case, pregnant women with a low-socioeconomic background experience challenges seeking information on pregnancy, leaving gaps in their knowledge about maternity health [17]. Thus, a user-only-centered design approach would limit the knowledge we could use in our interventions [18]. Therefore, expertise from specialized health care professionals must be included in any design process for health technologies.

Additionally, health care resources, even in developed nations with highly sophisticated and complex health care systems, are frequently scarce. Population growth requires investment in health care technologies.

However, those that are not well designed—no matter how effective—are unlikely to be used by patients, families, and other consumers. In this work, the first author brought this perspective to the project after an initial prototype was developed but long before final product testing. Thus, surveys and interviews could still be deployed, providing key insights that will be incorporated into the next iteration of the intervention but likely would have been more effective even earlier. HCI researchers and practitioners must demonstrate their value and make legible their contributions to others in these interdisciplinary projects. However, broader education of funding agencies and regulatory bodies can also enable better engagement with usability processes and procedures, such as is being proposed within the FDA in the US now [19].

### Conclusion and Further Research

Wearable technology can be used to track and measure behavior change for pregnant women. Data collected from wearable technology can provide greater insight for maternal health care. These insights arose from testing with community health workers of an initial prototype. However, these insights might more efficiently have been gained by earlier engagement with user experience and HCI researchers. In this paper, we reflect on the mission and results of an early phase of an interdisciplinary research project and what we as the HCI community can do to provide insight and support at any stage in such an effort as well as to advocate for earlier engagement. Our findings point to the call for understanding the needs of the studied population alongside deep technological and clinical expertise. This case study provides additional evidence for and reflection on the need, challenges, and opportunities of HCI researchers engage in

interdisciplinary health information technology interventions and research efforts.

### Acknowledgements

We gratefully acknowledge support of the National Science Foundation (NSF) through the Smart and Connected Communities (S&CC) grant CNS-1831918. This work was supported by the Competitive Edge program at UC Irvine. We are appreciative of the administrators and staff members of MOMS Orange County for their assistance with study recruitment and participation.

### References

- [1] Vanessa B Sheppard, Ruth E Zambrana, Ann S O'Malley, Providing health care to low-income women: a matter of trust, *Family Practice*, Volume 21, Issue 5, October 2004, Pages 484–491.
- [2] Jewell, N. A., & Russell, K. M. (2000). Increasing access to prenatal care: an evaluation of minority health coalitions' early pregnancy project. *Journal of Community Health Nursing*, 17(2), 93-105.
- [3] Recio, G. M., Garcia-Hernandez, L., Luque, R. M., & Salas-Morera, L. (2016). The role of interdisciplinary research team in the impact of health apps in health and computer science publications: a systematic review. *Biomedical engineering online*, 15(1), 77.
- [4] Erika S. Poole, HCI and mobile health interventions: How human–computer interaction can contribute to successful mobile health interventions, *Translational Behavioral Medicine*, Volume 3, Issue 4, December 2013, Pages 402–405.
- [5] Klawe, M., & Shneiderman, B. (2005). Crisis and opportunity in computer science. *Communications of the ACM*, 48(11), 27-28.

- [6] Nemcek, M. A. and Sabatier, . R. (2003), State of Evaluation: Community Health Workers. *Public Health Nursing*, 20: 260-270.
- [7] DeRenzi, B. , Borriello, G. , Jackson, J. , Kumar, V. S., Parikh, T. S., Virk, P. and Lesh, N. (2011), Mobile Phone Tools for Field-Based Health care Workers in Low-Income Countries. *Mt Sinai J Med*, 78: 406-418.
- [8] Braun R, Catalani C, Wimbush J, Israelski D (2013) Community Health Workers and Mobile Technology: A Systematic Review of the Literature. *PLOS ONE* 8(6)
- [9] Penders, J., Altini, M., Van Hoof, C., & Dy, E. (2015). Wearable sensors for healthier pregnancies. *Proceedings of the IEEE*, 103(2), 179-191.
- [10] Dunne, L. E., Ashdown, S. P., & Smyth, B. (2005). Expanding garment functionality through embedded electronic technology. *Journal of Textile and Apparel Technology and Management*, 4(3), 1-11.
- [11] Balaam, M., Robertson, J., Fitzpatrick, G., Say, R., Hayes, G., Mazmanian, M., & Parmar, B. (2013, April). Motherhood and HCI. In *CHI'13 extended abstracts on human factors in computing systems* (pp. 3215-3218). ACM.
- [12] Peyton, T., Poole, E., Reddy, M., Kraschnewski, J., & Chuang, C. (2014, June). Every pregnancy is different: designing mHealth for the pregnancy ecology. In *Proceedings of the 2014 conference on Designing interactive systems* (pp. 577-586). ACM.
- [13] Bardzell, S., & Bardzell, J. (2011, May). Towards a feminist HCI methodology: social science, feminism, and HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 675-684). ACM.
- [14] Gharaibeh, M., Al-Ma'aitah, R., & Al Jada, N. (2005). Lifestyle practices of Jordanian pregnant women. *International Nursing Review*, 52(2), 92-100.
- [15] Rauterberg, M. (2006). HCI as an engineering discipline: to be or not to be!?. *African Journal of Information & Communication Technology*, 2(4).
- [16] Epstein, R. M. (2000). The science of patient-centered care. *Journal of Family Practice*, 49(9), 805-810.
- [17] McNamee, P., Ternent, L., & Hussein, J. (2009). Barriers in accessing maternal healthcare: evidence from low-and middle-income countries. *Expert review of pharmacoeconomics & outcomes research*, 9(1), 41-48.
- [18] Klasnja, Predrag & Consolvo, Sunny & Pratt, Wanda. (2011). How to evaluate technologies for health behavior change in HCI research. *Conference on Human Factors in Computing Systems - Proceedings*. 3063-3072.
- [19] Shuren, J., Patel, B., & Gottlieb, S. (2018). FDA regulation of mobile medical apps. *Jama*, 320(4), 337-338.